

The Evolution and Long-Term Results of Laparoscopic Antireflux Surgery for the Treatment of Gastroesophageal Reflux Disease

C.S. Davis, A. Baldea, J.R. Johns, R.J. Joehl, P.M. Fisichella

ABSTRACT

Background: For nearly 2 decades, the laparoscopic correction of gastroesophageal reflux disease (GERD) has demonstrated its utility. However, the surgical technique has evolved over time, with mixed long-term results. We briefly review the evolution of antireflux surgery for the treatment of GERD, provide an update specific to the long-term efficacy of laparoscopic antireflux surgery (LARS), and analyze the factors predictive of a desirable outcome.

Materials and Methods: PubMed and Medline database searches were performed to identify articles regarding the laparoscopic treatment of GERD. Emphasis was placed on randomized control trials (RCTs) and reports with follow-up >1 year. Specific parameters addressed included operative technique, resolution of symptoms, complications, quality of life, division of short gastric vessels (SGVs), mesh repair, and approximation of the crura. Those studies specifically addressing follow-up of <1 year, the pediatric or elderly population, redo fundoplication, and repair of paraesophageal hernia and short esophagus were excluded.

Results: LARS has varied in technical approach through the years. Not until recently have more long-term, objective studies become available to allow for evidenced-based appraisals. Our review of the literature found no long-term difference in the rates of heartburn, gas-bloat, antacid use, or patient satisfaction between laparoscopic Nissen and Toupet fundoplication. In addition, several studies have shown that more patients had an abnormal pH profile following laparoscopic partial as opposed to total fundoplication. Conversely, dysphagia was more common following laparoscopic total versus partial fundoplication in 50% of RCTs at 12-month follow-up, though

this resolved over time, being present in only 20% with follow-up >24 months. We confirmed that preoperative factors, such as hiatal hernia, atypical symptoms, poor antacid response, body mass index (BMI), and postoperative vomiting, are potential predictors of an unsatisfactory long-term outcome. Last, no trial disfavored division of the short gastric vessels (SGVs), closure of the crura, or mesh repair for hiatal defects.

Conclusion: LARS has significantly evolved over time. The laparoscopic total fundoplication appears to provide more durable long-term results than the partial approach, as long as the technical elements of the operation are respected. Division of the SGVs, closure of the crura, and the use of mesh for large hiatal defects positively impacts long-term outcome. Hiatal hernia, atypical symptoms, poor antacid response, body mass index (BMI), and postoperative vomiting are potential predictors of failure in LARS.

Key Words: GERD, Gastroesophageal reflux disease, LARS, Laparoscopic antireflux surgery, Randomized controlled trials, RCT, Nissen fundoplication.

INTRODUCTION

Rudolph Nissen was the first to pioneer antireflux surgery in 1956.¹ His initial 360° approach would subsequently come to be modified by André Toupet,² Jacques Dor,³ Vicente Guarner,⁴ and Mario Rossetti.⁵ The premise for the modification of Nissen's original technique was to address various complications unique to antireflux surgery (such as dysphagia and gas-bloat syndrome) and disease processes of the esophagus (such as disorders of motility).

In 1991, the laparoscopic approach to antireflux surgery was moved forward by Bernard Dallemagne.⁶ By the time that Dallemagne and others were publishing their first reports of laparoscopic antireflux surgery (LARS) in the early 1990s, the utility in controlling gastroesophageal reflux disease (GERD) by open fundoplication had been established.⁷⁻⁹ However, even after 3 decades of antireflux surgery, much contention persisted as to which variation of fundoplication to use.¹⁰⁻¹² Unfortunately, this

Department of Surgery, Loyola University Medical Center, Maywood, Illinois (all authors).

Address correspondence to: Piero M. Fisichella, MD, Swallowing Center, Department of Surgery, Stritch School of Medicine, Loyola University Medical Center, 2160 South First Avenue - Room 3226, Maywood, IL 60153, USA. Telephone: (708) 327-2236, Fax: (708) 327-3492, E-mail: pfisichella@lumc.edu

DOI: 10.4293/108680810X12924466007007

© 2010 by JLS, *Journal of the Society of Laparoendoscopic Surgeons*. Published by the Society of Laparoendoscopic Surgeons, Inc.

contention has carried over to the laparoscopic era of antireflux surgery, and seems to persist to this day.^{13–15} Varin et al,¹⁶ in their recent metaanalysis of total versus partial fundoplication for GERD, concluded that many trials are of insufficient quality, are lacking in objectivity, and are too heterogeneous to reliably come to a serious consensus on the best operative technique and their predictors of success. Until larger, more objective studies come forth, Varin et al furthermore concluded that the laparoscopic antireflux approach be tailored to the surgeon's comfort level, based on evidence that still remains limited.

The goal of this review is to provide an additional avenue of clarity regarding paradigm shifts in LARS, long-term outcomes of laparoscopic fundoplication, and predictors of a successful surgical outcome.

MATERIALS AND METHODS

PubMed and Medline database searches were performed to obtain articles regarding both open and laparoscopic anti-reflux surgery for the treatment of GERD with follow-up >1 year. The searched articles appeared in print between January 1951 and December 2009. All articles appeared in peer-reviewed journals. The key words utilized in the search are as follows: "surgery/gastroesophageal reflux disease," "laparoscopic surgery/gastroesophageal reflux disease," "laparoscopic surgery/gastroesophageal reflux disease/long-term results," "laparoscopic surgery/gastroesophageal reflux disease/failure," and "laparoscopic surgery/gastroesophageal reflux disease/randomized trial." Additional articles were obtained via a manual search of the references included in the essential articles. Articles related to the following were excluded: short esophagus, paraesophageal hernia, redo-fundoplication, those converted to open, trials with <1 year of follow-up, and those specific to either elderly or pediatric patients. The following were parameters that were analyzed: criteria for patient selection, partial versus total fundoplication, changes in the standard of practice, and long-term results or effectiveness with respect to the amelioration of symptoms, recurrence of symptoms, and anatomic failure.

RESULTS

Evolution of Antireflux Surgery and Paradigm Shifts in LARS

The initial surgical approach to the refluxing patient began with Philip Allison in 1951, and his attempt at hiatal hernia repair.¹⁷ His thoracic approach, posterior crural repair, and left phrenic nerve crush would fall into disfa-

vor because of the poor patient outcome and high recurrence of hiatal hernia. The most proper beginnings, therefore, began with Nissen's report on fundoplication in 1956.¹ This technique of fundoplication, involving a 360° wrap and gastropexy for the treatment of hiatal hernias, was adopted shortly thereafter as an acceptable anti-reflux procedure within the surgical community. Later, variations of the technique were described by others, such as Dor from Marseille, who posited a partial anterior fundoplication for the treatment of achalasia in 1962.³

Although Nissen's procedure improved reflux symptoms, it soon became evident that some patients who underwent a total fundoplication were troubled by dysphagia, bloating, and the inability to belch, the so-called "gas-bloat syndrome." To avoid these side effects, in 1963 André Toupet advocated for the creation of a posterior partial (270°) fundoplication, termed a "semi-fundoplicative maneuver."² Baue and Belsey¹⁸ and Hill¹⁹ would follow in 1967, with their approaches aimed at restoring the normal physiology of the lower esophageal sphincter (LES). In 1975, Vicente Guarner from Mexico described a posterior fundoplasty in which the fundus of the stomach was passed behind the esophagus, thus forming between the esophagus and the right aspect of the fundus a 120° angle in the left upper quadrant on an imaginary circle. This procedure did not require division of the SGVs.⁴ Subsequently, Rossetti⁵ proposed in 1977 a revision that included a modified total fundoplication with minimal-dissection of the cardia and no division of the SGVs.

Unfortunately, these modifications still did not address recognized issues of postoperative dysphagia and the "gas-bloat" syndrome, for which Donahue and Bombeck pursued, with success, a "floppy Nissen."²⁰ DeMeester would soon recognize the benefits of this approach and publish his modifications and successful outcomes in 1986.¹² In the 1990s, the advent of laparoscopic surgery revolutionized the surgical approach to the patient with GERD when the laparoscopic Nissen fundoplication was described by Dallemagne in 1991 (**Figure 1**).⁶ Soon thereafter, many modifications of the laparoscopic Nissen fundoplication were developed, by replicating laparoscopically the original modifications of the open techniques.

From 1991, then, the application of laparoscopic Nissen fundoplication for the treatment of GERD would undergo its own paradigm shifts. During the early stages of LARS, many agreed that those patients with esophageal dysmotility were at risk for dysphagia, and a "tailored approach" came into vogue.²¹ However, the report in 1999 by Horvath et al¹⁴ would dispel this myth, as they demonstrated

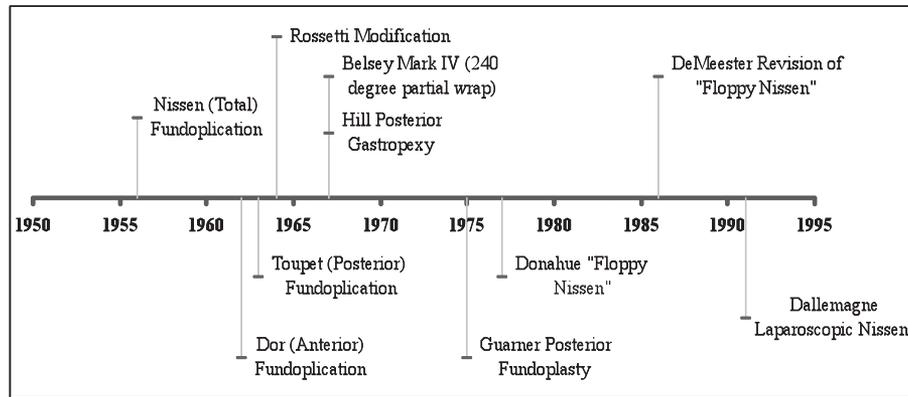


Figure 1. Evolution of fundoplication.

reflux in 46% after partial fundoplication. The studies by Fibbe et al in 2001²² and Patti et al in 2004²³ would confirm these findings, and the “tailored approach” would become disfavored. Finally, in an attempt to address an elevated prevalence of early dysphagia following total fundoplication, the “floppy” laparoscopic Nissen fundoplication seems to have become favored by many as the standard surgical procedure regardless of preoperative esophageal function, with a partial fundoplication reserved for those with achalasia and scleroderma without esophageal peristalsis (**Figure 2**).²⁴

Long-Term Results of LARS

From 1997 through 2009, 13 randomized control trials (RCTs) were identified that assessed the outcome of LARS (**Table 1**).^{25–37} Four^{26,28,32,36} of these 13 RCTs demonstrated follow-up of 60 months or more. The surgical approach varied considerably: Nissen versus anterior fundoplication, (3) Nissen-Rossetti versus anterior fundoplication, (3) Nissen versus Toupet, (6) Toupet versus anterior fundoplication, (2) and Nissen versus Nissen-Rossetti.

(1) Two studies included were longer-term assessments of the same patient population that had been previously reported at least 12 months postoperatively. Initial sample size ranged from 39 to 200 patients.

There was no long-term difference for relief of heartburn in any study that evaluated total versus partial fundoplication, suggesting that both techniques equally resolve typical symptoms of GERD. Hagedorn et al²⁵ and Engström et al²⁶ found a higher prevalence of postoperative heartburn in patients after the anterior fundoplication as opposed to the posterior fundoplication, both at 12 months ($P < 0.001$) and 60 months (60% versus 24%, $P < 0.0001$).

All trials reported on the long-term incidence of dysphagia following LARS. Assessment for dysphagia was performed in a varied fashion, though most often by visual analogue scale (VAS) or questionnaire. Not all studies reported dysphagia to solids and liquids independently. In 2 of 3 studies assessing Nissen versus anterior fundoplication and in the study assessing Nissen-Rossetti versus anterior fundoplication, patients at long-term follow-up displayed

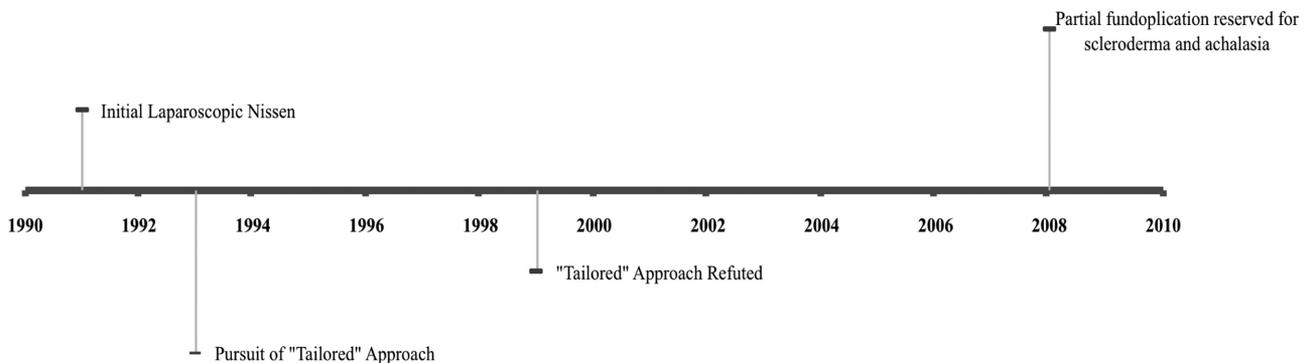


Figure 2. Paradigm shifts in laparoscopic antireflux surgery.

Table 1. Long-term Outcome of Laparoscopic Antireflux Surgery for Gastroesophageal Reflux Disease Based on Randomized Control Trials

Study Author (Year)	N	Follow-up (months)	Procedure Type	Major Morbidity	Re-operation	Dysphagia to Solids	Dysphagia to Liquids	Heartburn	Gas Bloat	Post-op pH Studies	Post-op H2-Blockers or Proton Pump Inhibitors	Satisfaction (Percent or Score)
Baigrie, 2005 ²⁷	163	24	Nissen Anterior	-	4	0.6 ^{ab}	0.1 ^b	0.2 ^c	NS	-	-	9.6
Ludemann, 2005 ²⁸	107	60	Nissen Anterior	-	3	2.6 ^{ab}	1.0 ^b	1.8 ^c	NS	-	12%	9.7
Cai, 2008 ³²	107	120	Nissen Anterior	-	5	1.5 ^{ab}	0.6 ^b	1.9 ^c	NS	-	4%	8.0
Spence, 2006 ²⁹	100	12	Nissen-Rossetti Anterior	7	3	4.9% ^a	1.0 ^b	2.3 ^c	NS	0% ^a	27%	8.2
Laws, 1997 ³³	39	27 (Mean)	Nissen Toupet	0	2	13% ^a	0	16%	-	0.7% ^a	4%	9.6
Guérin, 2007 ³⁴	140	36	Nissen Toupet	0	-	NS ^e	-	-	-	-	0%	100%
Booth, 2008 ³⁰	127	12	Nissen Toupet	0	2%	2	0	4	NS	-	-	91%
Strate, 2008 ³¹	200	24	Nissen Toupet	3%	15 ^a	27% ^{abc}	0	3	NS	0.1% ^a	-	89%
Mickevicius, 2008 ³⁵	153	12	Nissen Toupet	2	3%	9% ^{abc}	-	24%	25%	0.4% ^a	-	85%
Shaw, 2009 ³⁶	100	55-60 (Mean)	Nissen Toupet	5	4	19 ^a	-	-	13%	20 ^g	7% ^g	85%
Hagedorn, 2003 ²⁵	95	12	Nissen Toupet	-	3	8 ^{abc}	-	-	-	15 ^g	9% ^g	-
Engström, 2007 ²⁶	95	60	Nissen Toupet	-	1	NS ^e	-	NS	NS	-	2	NS
Chryso, 2001 ³⁷	78	12	Nissen-Rossetti	1	-	NS ^e	-	Favors Toupet ^a	-	-	1	-
								24% ^a	-	-	7% ^a	93% ^a
								60% ^a	-	-	23% ^a	59% ^a
								4%	38%	-	-	NS
								0%	19%	-	-	-

^aIndicates significance, P≤0.05.

^bDysphagia based on visual analogue scale.

^cHeartburn based on visual analogue scale.

^dNot stratified by operative technique.

^eDistinction between dysphagia to solids or liquids not made.

^fTrend toward significance.

^gSignificance not reported.

^hRCT=Randomized control trial; NS=No significance between groups; Dashes=no data recorded.

an increased prevalence of dysphagia to solids.^{27–29} This phenomenon was mirrored in some respects by those trials evaluating Nissen fundoplication versus Toupet, whereby 2 of 6 studies^{30,31} again demonstrated an increased prevalence of dysphagia in the Nissen group. No difference was demonstrated between anterior fundoplication and Toupet, or Nissen and Nissen-Rossetti. Of note, in only 1 of 5 trials of longer than 2-year follow-up comparing total versus partial fundoplication was there a significant difference in dysphagia.²⁸

Nine of the 13 trials reported on gas-bloat, with none demonstrating a difference between groups. Postoperative pH testing was not commonly reported, as data were reported in only 3 of the 13 trials. In 2 of these, there appeared to be a protective effect against reflux for total rather than partial fundoplication.^{29,30} Both of these studies had only shorter follow-up, thus further long-term results are difficult to discern. None of these studies reporting on postoperative pH testing reported postoperative use of histamine blockers or proton pump inhibitors (PPIs), though 6 others did. Of these, only the study by Engström et al²⁶ noted any difference in antisecretory use, which occurred at 60 months with a higher prevalence in anterior fundoplication versus Toupet, coinciding with a higher prevalence of heartburn. No difference was found for total versus partial fundoplication in the postoperative use of antacid therapy.

Last, 10 of the 13 randomized control trials reported on patient satisfaction, either by percentage satisfied or score. Again, Engström et al²⁶ noted a difference in their study at 60 months, with more patients having undergone anterior fundoplication versus Toupet demonstrating their dissatisfaction. However, in all trials comparing total versus partial fundoplication, there was no difference in patient satisfaction, which remained high at long-term follow-up regardless of the approach.

LARS appears to be associated with minimal morbidity, most often in less than 5% of cases. The group studied by Spence et al²⁹ experienced the highest rate of morbidity in any single category; however, the 7% morbidity in the Nissen-Rossetti group did not reach significance compared with the 2% experienced in the anterior fundoplication group. The necessity of reoperation was similarly infrequent throughout the studies, with the exception being the study of Strate et al.³¹ This group reported 19 reoperations for patient dissatisfaction (10% of study group, 15 who underwent Nissen and 4 who underwent Toupet, $P < 0.05$). All patients were found to have a wrap herniation from disrupted hiataloplasty.

Factors Predictive of LARS Failure

Various pre- and postoperative features are commonly implicated in the failure of LARS (**Table 2**).^{14,31,38–50} In those studies identifying such potential predictors, the laparoscopic approach to antireflux intervention was varied. Preoperative disorders of peristalsis appeared to be the weaker predictor of LARS failure, reaching statistical significance in only 1 of 5 studies.³⁸ On the contrary, the presence preoperatively of atypical symptoms, poor response to preoperative antacids, and postoperative vomiting, indicated a more pronounced predictive value, occurring in over 60% of included studies. Body mass index (BMI) >30 or 35 was correlated with poor operative outcome in 33% of studies. Finally, the presence of hiatal hernias >3 cm was a predictor of failure in 38% of the studies.

Over the years, specific details of the operative techniques that are independent of the skills of the surgeon and that may impact outcome have been identified (**Table 3**).^{37,38,40,51–61} The studies we reviewed had a large sample size, adequate follow-up, and addressed each technical variable specifically. Although some differences were noted as to the predictive value of each technical variable, no study disfavored division of the SGVs, closure of the crura, or mesh repair for hiatal defects.^{37,38,40,51–55}

DISCUSSION

Antireflux surgery has been an evolving process for over half a century. Changes in technique were aimed at improving patient outcome and satisfaction. Starting with the laparoscopic age of antireflux surgery in 1991, paradigms in technique and patient approach shifted along the lines of technological advance. Oftentimes, information gleaned from postoperative follow-up was for <1 year, limiting the surgeon's perspective as to the true outcome of a particular modification in technique. Unfortunately, this methodology carried over from the previous 30 or so years of antireflux surgery, whereby objectivity in the form of RCTs was few and far between. Presently, we are on the cusp of 2 full decades of experience with LARS. Though the “tailored approach” has fallen into disfavor, there is still no true international consensus on the basic technique of total versus partial fundoplication; however, some evidence suggests that a partial fundoplication ought to be reserved for those with achalasia and GERD secondary to scleroderma.²⁴ Indeed, LARS has come full circle to using the same concept of a “floppy” Nissen proposed by Donahue⁸ and DeMeester¹² before laparoscopy was even introduced.

Table 2.
Predictors of Laparoscopic Antireflux Surgery Failure

Study Author (Year)	N	Procedure Type	Disorders of Peristalsis	Hiatal Hernia	Atypical Symptoms	Poor Response to Antacids	BMI	Postoperative Vomiting
Bell, 1999 ³⁸	143	Toupet	p=0.003	–	–	–	NS	–
Campos, 1999 ³⁹	199	Nissen	0% Failure	12% ^c Failure	p=0.0001	p<0.05	NS ^{d,e}	–
Horvath, 1999 ¹⁴	48	Toupet	7% Failure	64% ^b Failure	–	–	–	–
Soper, 1999 ⁴⁰	290	Nissen	–	p<0.005 ^b	NS	–	–	p<0.0001
Jackson, 2001 ⁴¹	100	Nissen (77) Toupet (4)	NS	NS ^c	p<0.002	p<0.0007	–	–
Perez, 2001 ⁴²	187	Nissen	–	–	–	–	p=0.03	–
Hahnloser, 2002 ^{f,43}	126	Nissen	–	NS ^b	NS	–	p<0.05	20% ^e Failure
Winslow, 2003 ⁴⁴	505	Varied	–	–	–	–	NS	–
Power, 2004 ⁴⁵	131	Nissen	–	p<0.001 ^b	–	p<0.001	–	–
D'Alessio, 2005 ⁴⁶	257	Nissen	–	–	–	–	NS	–
Iqbal, 2006 ⁴⁷	41 Case 50 Control	Nissen	–	50% ^{a,b} Failure	–	42% Failure	NS	29% ^a Failure
Morgenthal, 2007 ⁴⁸	174	Nissen	–	25% ^{b,c} Failure	59% ^a Failure	44% ^a Failure	57% ^a Failure	–
Antoniou, 2008 ⁴⁹	32	Nissen	–	–	–	5% Failure	–	–
Strate, 2008 ³¹	200	Nissen (100) Toupet (100)	17% Failure	–	–	–	–	–
Chisholm, 2009 ⁵⁰	481	Varied	–	–	–	–	NS	–

^aSignificant difference at least P<0.05.

^bHiatal hernia >3 cm.

^cSize of hiatal hernia not mentioned, or <2 cm.

^d100% of patients with BMI >38 had poor outcome.

^eSignificance not reported.

^fStudy based on postoperative complications.

^gPredictors are defined as demonstrating failure of physiologic improvement, patient dissatisfaction, or necessity of reoperation.

^hBMI=Body Mass Index; NS=Not significant; Dashes=no data recorded.

Our review of RCTs for long-term outcome in LARS was hampered by an impoverished standardization in reporting morbidity and reoperation, as well as in standardization of outcome assessment. Studies relied heavily on subjective determinations of postoperative dysphagia, gas-bloat, heartburn, and overall patient satisfaction, leaving comparison of these parameters between trials ardu-

ous. The most consistent objectivity that we found was in the analysis of postoperative pH testing, manometry, and use of H2-blockers or PPIs, though the intertrial consistency of these objective parameters is questionable. Nonetheless, particular patterns are apparent and consistent.^{14,24,62} First, either laparoscopic total or partial fundoplication result in equivalently low rates of heart-

Table 3.
Operative Technique and Laparoscopic Antireflux Surgery

Study Author (Year)	N	Procedure Type	Division of Short Gastrics	Closure of Crura	Mesh Repair
Bell, 1999 ³⁸	143	Toupet	Favors ^a Division	ND	–
Soper, 1999 ⁴⁰	290	Variable Nissen (53), Standard Nissen (237)	Favors Division	Favors ^a Closure	–
Blomqvist, 2000 ⁵⁹	99	Nissen	ND	–	–
Mardani, 2009 ⁶⁰	99	Nissen	ND	–	–
Chrysos, 2001 ³⁷	78	Nissen, Nissen-Rossetti	ND	–	–
Kamolz, 2002 ⁵¹	200	Nissen	–	–	Favors
Granderath, 2005 ⁵²	100	Nissen	–	–	Mesh Favors Mesh
Turkcaper, 2007 ⁵⁴	551	Toupet	–	–	Favors Mesh
Farah, 2007 ⁵⁶	90	Nissen	ND	–	–
O'Boyle, 2002 ⁵⁷	102	Nissen	ND	–	–
Yang, 2008 ⁵⁸	102	Nissen	ND	–	–
Köse, 2009 ⁶¹	41	Nissen	ND	–	–
Soricelli, 2009 ⁵⁵	297	Varied	–	–	Favors Mesh

^aStatistically significant.

^bN=Number of patients, ND=No difference.

^cDashes=no data recorded.

burn at long-term follow-up. Only one group undertook long-term randomized comparison of 2 partial approaches to fundoplication. In anterior versus posterior fundoplication, Engström et al²⁶ demonstrated more heartburn after the anterior approach, which persisted to 60 months. Not surprisingly, those patients in the anterior fundoplication group were more likely to require medical management of their recurrent disease and to be significantly dissatisfied with their results. Second, most RCTs demonstrated a higher incidence of postoperative dysphagia with total fundoplication as opposed to partial fundoplication, yet this persisted in only 1 of 5 trials with greater than 24 months of follow-up.²⁸ Third, those few studies that reported on postoperative esophageal pH testing data showed that partial fundoplication resulted in a higher prevalence of acid reflux than total fundoplication did at long-term follow-up.^{29,30} This is in line with the current understanding that dysphagia with total fundoplication is

more common, yet that it diminishes overtime, affording the patient a greater likelihood of freedom from acid reflux with no difference in heartburn or gas-bloat.

We also sought to identify the factors predictive of LARS failure (**Tables 2 and 3**). Many of the studies suggested that large hiatal hernias, atypical symptoms, poor response to medical reflux management, an elevated BMI, and postoperative vomiting are potential predictors for long-term failure. Interestingly, only the group in the Bell et al study,³⁸ that used a posterior fundoplication, noted any increased rate of failure for those with disorders of peristalsis, in line with the notion that a tailored approach is unnecessary. In addition, the DeMeester score, the presence of Barrett's esophagus and esophagitis, and a defective LES have all been additionally implicated as independent predictors in some series, though this is not uniform throughout the stud-

ies.^{14,37,41,48} Similarly, variations in technique, including division of the SGVs, closure of the crura, and prosthetic repair of the hiatus may influence long-term outcomes. Indeed, no study identified a benefit to leaving the SGVs intact, and Bell et al³⁸ and Soper et al⁴⁰ found statistical differences to favor their division. Shorter-term studies and the metaanalysis by Catarci et al uphold this conclusion.^{63,64} Last, some reports have focused on the utility of prosthetic closure of the hiatus, with a consensus in favor of using mesh for this purpose.^{51–55} However, a recent case series by Stadlhuber et al⁶⁵ places a caveat on the use of mesh, and given their findings they propose multicenter prospective studies to further validate its use.

Finally, it is the authors' position that tailoring of technique to weak peristalsis should not be routinely practiced except in the face of achalasia or GERD secondary to scleroderma. In addition, we favor complete mobilization of the gastric fundus and meticulously approximated crural pillars. Our approach is that supported by the best attempts to interpret the limited body of consistent and objective literature regarding long-term outcomes in LARS.

CONCLUSION

Since its beginnings, LARS has been slow to assume an evidence-based understanding of fundoplication technique, and the approach has meandered from variation to variation. Although we are now afforded more objectivity by way of esophageal testing and a handful of long-term RCTs, a clear discrepancy remains in the laparoscopic approach, pre- and postoperative analysis, and report of study findings regarding the patient with GERD. Nevertheless, it appears that laparoscopic total fundoplication affords more durable long-term results than the partial fundoplication, provided that potential predictors of failure are identified early and that the technical elements of the operation are respected.

References:

1. Nissen R. Eine einfache Operation zur Beeinflussung der Refluxoesophagitis. *Schweiz Med Wochenschr.* 1956;86:590–592.
2. Toupet A. Technic of esophago-gastroplasty with phrenogastropey used in radical treatment of hiatal hernias as a supplement to Heller's operation in cardiospasm. *Mem Acad Chir (Paris).* 1963;89:384–389.
3. Dor J, Humbert P, Dor V, Figarella J. L'interet de la technique de Nissen modifiee dans la prevention du reflux apres cardio-

myotomie extramuqueuse de Heller. *Mem Acad Chir (Paris).* 1962;3:877–883.

4. Guarner V, Degollade JR, Tore NM. A new antireflux procedure at the esophagogastric junction: experimental and clinical evaluation. *Arch Surg.* 1975;110(1):101–106.

5. Rossetti M, Hell K. Fundoplication for the treatment of gastroesophageal reflux in hiatal hernia. *World J Surg.* 1977;1(4):439–443.

6. Dallemagne B, Weerts JM, Jehaes C, Markiewicz S, Lombard R. Laparoscopic Nissen fundoplication: preliminary report. *Surg Laparosc Endosc.* 1991;1(3):138–143.

7. Spechler SJ. Comparison of medical and surgical therapy for complicated gastroesophageal reflux disease in veterans. The Department of Veterans Affairs Gastroesophageal Reflux Disease Study Group. *N Engl J Med.* 1992;326(12):786–792.

8. Donahue PE, Samelson S, Nyhus LM, Bombeck CT. The floppy Nissen fundoplication. Effective long-term control of pathologic reflux. *Arch Surg.* 1985;120(6):663–668.

9. Henderson RD, Marryatt G. Total fundoplication gastroplasty. Long-term follow-up in 500 patients. *Thorac Cardiovasc Surg.* 1983;85(1):81–87.

10. Shirazi SS, Schulze K, Soper RT. Long-term follow-up for treatment of complicated chronic reflux esophagitis. *Arch Surg.* 1987;122(5):548–552.

11. Thor KB, Silander T. A long-term randomized prospective trial of the Nissen procedure versus a modified Toupet technique. *Ann Surg.* 1989;210(6):719–724.

12. DeMeester TR, Bonavina L, Albertucci M. Nissen fundoplication for gastroesophageal reflux disease. Evaluation of primary repair in 100 consecutive patients. *Ann Surg.* 1986;204(1):9–20.

13. Watson DI, Jamieson GG, Pike GK, Davies N, Richardson M, Devitt PG. Prospective randomized double-blind trial between laparoscopic Nissen fundoplication and anterior partial fundoplication. *Br J Surg.* 1999;86(1):123–130.

14. Horvath KD, Jobe BA, Herron DM, Swanstrom LL. Laparoscopic Toupet fundoplication is an inadequate procedure for patients with severe reflux disease. *J Gastrointest Surg.* 1999;3(6):583–591.

15. Shaw JM, Bornman PC, Callanan MD, Beckingham IJ, Metz DC. Long-term outcome of laparoscopic Nissen and laparoscopic Toupet fundoplication for gastroesophageal reflux disease: a prospective, randomized trial. *Surg Endosc.* 2009 Sep 30. [Epub ahead of print]

16. Varin O, Velstra B, De Sutter S, Ceelen W. Total vs partial fundoplication in the treatment of gastroesophageal reflux disease: a meta-analysis. *Arch Surg.* 2009;144(3):273–278.

17. Allison PR. Reflux esophagitis, sliding hiatal hernia, and the anatomy of repair. *Surg Gynecol Obstet.* 1951;92(4):419–431.

18. Baue J, Belsey RHR. The treatment of sliding hiatus hernia and reflux esophagitis by the Mark IV technique. *Surgery*. 1967;62:396–406.
19. Hill LD. An effective operation for hiatal hernia: an eight year appraisal. *Ann Surg*. 1967;166:681–92.
20. Donahue PE, Bombeck PT. The modified Nissen fundoplication – reflux prevention without gas bloat. *Rev Surg*. 1977;11:15–27.
21. Kauer WK, Peters JH, DeMeester TR, Heimbucher J, Ireland AP, Bremner CG. A tailored approach to antireflux surgery. *J Thorac Cardiovasc Surg*. 1995;110(1):141–147.
22. Fibbe C, Layer P, Keller J, Strate U, Emmermann A, Zornig C. Esophageal motility in reflux disease before and after fundoplication: a prospective, randomized, clinical, and manometric study. *Gastroenterology*. 2001;121(1):5–14.
23. Patti MG, Robinson T, Galvani C, Gorodner MV, Fisichella PM, Way LW. Total fundoplication is superior to partial fundoplication even when esophageal peristalsis is weak. *J Am Coll Surg*. 2004;198(6):863–870.
24. Patti MG, Gasper WJ, Fisichella PM, Nipomnick I, Palazzo F. Gastroesophageal reflux disease and connective tissue disorders: pathophysiology and implications for treatment. *J Gastrointest Surg*. 2008;12(11):1900–1906.
25. Hagedorn C, Jönson C, Lönroth H, Ruth M, Thune A, Lundell L. Efficacy of an anterior as compared with a posterior laparoscopic partial fundoplication: results of a randomized, controlled clinical trial. *Ann Surg*. 2003;238(2):189–196.
26. Engström C, Lönroth H, Mardani J, Lundell L. An anterior or posterior approach to partial fundoplication? Long-term results of a randomized trial. *World J Surg*. 2007;31(6):1221–1227.
27. Baigrie RJ, Cullis SN, Ndhluni AJ, Cariem A. Randomized double-blind trial of laparoscopic Nissen fundoplication versus anterior partial fundoplication. *Br J Surg*. 2005;92(7):819–823.
28. Ludemann R, Watson DI, Jamieson GG, Game PA, Devitt PG. Five-year follow-up of a randomized clinical trial of laparoscopic total versus anterior 180 degrees fundoplication. *Br J Surg*. 2005;92(2):240–243.
29. Spence GM, Watson DI, Jamieson GG, Lally CJ, Devitt PG. Single center prospective randomized trial of laparoscopic Nissen versus anterior 90 degrees fundoplication. *J Gastrointest Surg*. 2006;10(5):698–705.
30. Booth MI, Stratford J, Jones L, Dehn TC. Randomized clinical trial of laparoscopic total (Nissen) versus posterior partial (Toupet) fundoplication for gastro-oesophageal reflux disease based on preoperative oesophageal manometry. *Br J Surg*. 2008;95(1):57–63.
31. Strate U, Emmermann A, Fibbe C, Layer P, Zornig C. Laparoscopic fundoplication: Nissen versus Toupet two-year outcome of a prospective randomized study of 200 patients regarding preoperative esophageal motility. *Surg Endosc*. 2008;22(1):21–30.
32. Cai W, Watson DI, Lally CJ, Devitt PG, Game PA, Jamieson GG. Ten-year clinical outcome of a prospective randomized clinical trial of laparoscopic Nissen versus anterior 180 (degrees) partial fundoplication. *Br J Surg*. 2008;95(12):1501–1505.
33. Laws HL, Clements RH, Swillie CM. A randomized, prospective comparison of the Nissen fundoplication versus the Toupet fundoplication for gastroesophageal reflux disease. *Ann Surg*. 1997;225(6):647–654.
34. Guérin E, Bétroune K, Closset J, et al. Nissen versus Toupet fundoplication: results of a randomized and multicenter trial. *Surg Endosc*. 2007;21(11):1985–1989.
35. Mickevicius A, Endzinas Z, Kiudelis M, et al. Influence of wrap length on the effectiveness of Nissen and Toupet fundoplication: a prospective randomized study. *Surg Endosc*. 2008;22(10):2269–2276.
36. Shaw JM, Bornman PC, Callanan MD, Beckingham IJ, Metz DC. Long-term outcome of laparoscopic Nissen and laparoscopic Toupet fundoplication for gastroesophageal reflux disease: a prospective, randomized trial. *Surg Endosc*. 2009 Sep 30. [Epub ahead of print].
37. Chrysos E, Tzortzinis A, Tsiaoussis J, Athanasakis H, Vassilakis J, Xynos E. Prospective randomized trial comparing Nissen to Nissen-Rossetti technique for laparoscopic fundoplication. *Am J Surg*. 2001;182(3):215–221.
38. Bell RC, Hanna P, Mills MR, Bowrey D. Patterns of success and failure with laparoscopic Toupet fundoplication. *Surg Endosc*. 1999;13(12):1189–1194.
39. Campos GM, Peters JH, DeMeester TR, et al. Multivariate analysis of factors predicting outcome after laparoscopic Nissen fundoplication. *J Gastrointest Surg*. 1999;3(3):292–300.
40. Soper NJ, Dunnegan D. Anatomic fundoplication failure after laparoscopic antireflux surgery. *Ann Surg*. 1999;229(5):669–677.
41. Jackson PG, Gleiber MA, Askari R, Evans SR. Predictors of outcome in 100 consecutive laparoscopic antireflux procedures. *Am J Surg*. 2001;181(3):231–235.
42. Perez AR, Moncure AC, Rattner DW. Obesity adversely affects the outcome of antireflux operations. *Surg Endosc*. 2001;15(9):986–989.
43. Hahnloser D, Schumacher M, Cavin R, Cosendey B, Petropoulos P. Risk factors for complications of laparoscopic Nissen fundoplication. *Surg Endosc*. 2002;16(1):43–47.
44. Winslow ER, Frisella MM, Soper NJ, Klingensmith ME. Obesity does not adversely affect the outcome of laparoscopic antireflux surgery (LARS). *Surg Endosc*. 2003;17(12):2003–2011.

45. Power C, Maguire D, McAnena O. Factors contributing to failure of laparoscopic Nissen fundoplication and the predictive value of preoperative assessment. *Am J Surg*. 2004;187(4):457–463.
46. D'Alessio MJ, Arnaoutakis D, Giarelli N, Villadolid DV, Rosemurgy AS. Obesity is not a contraindication to laparoscopic Nissen fundoplication. *J Gastrointest Surg*. 2005;9(7):949–954.
47. Iqbal A, Kakarlapudi GV, Awad ZT, et al. Assessment of diaphragmatic stressors as risk factors for symptomatic failure of laparoscopic Nissen fundoplication. *J Gastrointest Surg*. 2006;10(1):12–21.
48. Morgenthal CB, Lin E, Shane MD, Hunter JG, Smith CD. Who will fail laparoscopic Nissen fundoplication? Preoperative prediction of long-term outcomes. *Surg Endosc*. 2007;21(11):1978–1984.
49. Antoniou SA, Delivorias P, Antoniou GA, et al. Symptom-focused results after laparoscopic fundoplication for refractory gastroesophageal reflux disease—a prospective study. *Langenbecks Arch Surg*. 2008;393(6):979–984.
50. Chisholm JA, Jamieson GG, Lally CJ, Devitt PG, Game PA, Watson DI. The effect of obesity on the outcome of laparoscopic antireflux surgery. *J Gastrointest Surg*. 2009;13(6):1064–1070.
51. Kamolz T, Granderath FA, Bammer T, Pasiut M, Pointner R. Dysphagia and quality of life after laparoscopic Nissen fundoplication in patients with and without prosthetic reinforcement of the hiatal crura. *Surg Endosc*. 2002;16(4):572–577.
52. Granderath FA, Schweiger UM, Kamolz T, Asche KU, Pointner R. Laparoscopic Nissen fundoplication with prosthetic hiatal closure reduces postoperative intrathoracic wrap herniation: preliminary results of a prospective randomized functional and clinical study. *Arch Surg*. 2005;140(1):40–48.
53. Granderath FA, Carlson MA, Champion JK, et al. Prosthetic closure of the esophageal hiatus in large hiatal hernia repair and laparoscopic antireflux surgery. *Surg Endosc*. 2006;20(3):367–379.
54. Turkcapar A, Kepenekci I, Mahmoud H, Tuzuner A. Laparoscopic fundoplication with prosthetic hiatal closure. *World J Surg*. 2007;31(11):2169–2176.
55. Soricelli E, Basso N, Genco A, Cipriano M. Long-term results of hiatal hernia mesh repair and antireflux laparoscopic surgery. *Surg Endosc*. 2009 Apr 3. [Epub ahead of print].
56. Farah JF, Grande JC, Goldenberg A, Martinez JC, Lupinacci RA, Matone J. Randomized trial of total fundoplication and fundal mobilization with or without division of short gastric vessels: a short-term clinical evaluation. *Acta Cir Bras*. 2007;22(6):422–429.
57. O'Boyle CJ, Watson DI, Jamieson GG, Myers JC, Game PA, Devitt PG. Division of short gastric vessels at laparoscopic Nissen fundoplication: a prospective double-blind randomized trial with 5-year follow-up. *Ann Surg*. 2002;235(2):165–170.
58. Yang H, Watson DI, Lally CJ, Devitt PG, Game PA, Jamieson GG. Randomized trial of division versus nondivision of the short gastric vessels during laparoscopic Nissen fundoplication: 10-year outcomes. *Ann Surg*. 2008;247(1):38–42.
59. Blomqvist A, Dalenbäck J, Hagedorn C, Lönroth H, Hyltander A, Lundell L. Impact of complete gastric fundus mobilization on outcome after laparoscopic total fundoplication. *J Gastrointest Surg*. 2000;4(5):493–500.
60. Mardani J, Lundell L, Lönroth H, Dalenbäck J, Engström C. Ten-year results of a randomized clinical trial of laparoscopic total fundoplication with or without division of the short gastric vessels. *Br J Surg*. 2009;96(1):61–65.
61. Kösek V, Wykypiel H, Weiss H, et al. Division of the short gastric vessels during laparoscopic Nissen fundoplication: clinical and functional outcome during long-term follow-up in a prospectively randomized trial. *Surg Endosc*. 2009;23(10):2208–2213.
62. Oleynikov D, Eubanks TR, Oelschläger BK, Pellegrini CA. Total fundoplication is the operation of choice for patients with gastroesophageal reflux and defective peristalsis. *Surg Endosc*. 2002;16(6):909–913.
63. Hunter JG, Swanstrom L, Waring JP. Dysphagia after laparoscopic antireflux surgery. The impact of operative technique. *Ann Surg*. 1996;224(1):51–57.
64. Catarci M, Gentileschi P, Papi C, et al. Evidence-based appraisal of antireflux fundoplication. *Ann Surg*. 2004;239(3):325–337.
65. Stadlhuber RJ, Sherif AE, Mittal SK, et al. Mesh complications after prosthetic reinforcement of hiatal closure: a 28-case series. *Surg Endosc*. 2009;23(6):1219–1226.